Mapping of thermal quenching and luminescence lifetimes in phosphors at the microscopic level

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In the past decade, research into luminescent materials for use in white light emitting diodes (LEDs) has seen a tremendous increase. These conversion phosphors should fulfill a number of stringent requirements, including a quantum efficiency close to unity and good thermal stability. These properties are commonly determined on a macroscopic scale, i.e. involving a relatively large amount of phosphor material.

In this work we report on a study of the luminescence lifetime and the thermal quenching at the microscopic level, with submicron spatial resolution (Fig. 1). In this way, the emission properties are not averaged over a large area. This allows a more fundamental investigation of the luminescence behavior of individual phosphor particles. For this purpose, cathodoluminescence (CL) spectroscopy in a scanning electron microscope (SEM) was applied to a selected number of europium-doped phosphors, such as Ca_2SiS_4:Eu and $SrGa_2S_4$:Eu. By means of a pulsed electron beam blanker, a gatable CCD and a temperature stage, mappings of the luminescence lifetime and the thermal quenching were produced. It is shown that variations in both lifetime and thermal quenching are closely related to the local chemical composition and the dopant concentration, as monitored by energy-dispersive x-ray analysis (EDX). Finally, the relation with the quantum efficiency is discussed.

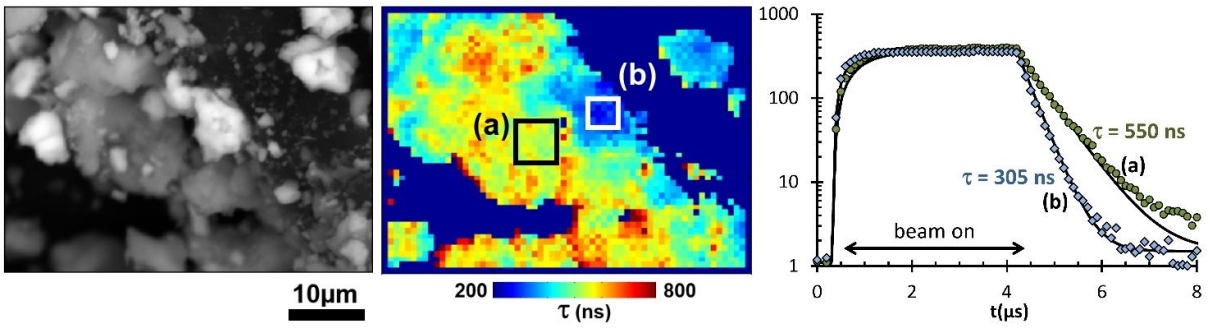

Fig. 1. Secondary electron image of a $(Ca,Eu)_2SiS_4$ phosphor **(left)**, CL lifetime mapping on the same area **(middle)** and detailed decay profiles upon pulsed CL excitation for the two highlighted areas in the middle figure **(right)**.